6

Organizing the System to Support Quality Science Education

The past several years have seen a renewed interest in issues associated with mathematics and science education. Spurred by a general sense that large numbers of the students in American schools are failing to acquire minimum levels of proficiency in mathematics and science, and concerned that this failure is contributing to the erosion of our country's economic competitiveness, a number of national organizations have called for reforms in both the content and delivery of mathematics and science courses in our schools and colleges. Perhaps the loudest call for change is contained in the National Goals for Education that were developed by President Bush and the nation's governors in 1990 and subsequently amended to become the basis for Goals 2000 legislation. Goal Number Four is that

"*By the year 2000, US. students will be first in the world in science and mathematics achievement.*"

At the present time, it is clear we are a long way from meeting this goal. Small numbers of American students can clearly compete with and outperform their counterparts from other nations of the world as events like the Physics and Chemistry International Olympiads demonstrate. The annual winners of the Westinghouse Science Talent Search produce projects and research-based scientific insights which are the envy of the world. However, the majority of our students are not performing anywhere close to these high levels of attainment.

In a society that is increasingly becoming information and technology based, it is imperative that students know and can apply important mathematics and science concepts. Our population must be able to intelligently examine ethical dilemmas such as gene therapy and biological weapons, and elect officials who can make wise public policy decisions about them. Scientific and technological literacy is becoming as important as the ability to read and write.

Yet, low overall student achievement levels "for the masses" are only one indication of the nation's problems in mathematics and science. Another sign of impending trouble is that the nation's colleges and universities are not graduating the number of needed students with degrees in mathematics and the physical sciences. Not only are fewer students being prepared than are needed, but nearly half of all those we do educate to the level of graduate degrees in science, mathematics and engineering are non-citizens (National Science Foundation, 1993). Compounding this problem even further is the fact that, as a group, US students who are science, mathematics and engineering graduates remain overwhelmingly white and male. Over the past 15 years, 95% of US students receiving degrees in the physical sciences have been white, and a vast majority of these are white males. Even apart from concerns about equity and justice, the evolving work force of this country which is increasingly female and minority--demands that a better job be done to encourage minorities and women to follow careers in mathematics and the sciences. If not, the current shortage of American scientists is certain to grow worse and become a fatal flaw in the nation's technological and economic growth.

"Operating on the principle that all children can learn, the focus on learning should emphasize students as life-long learners, as citizens and as workers. The goal is to develop students who will function as caring and productive citizens. Specifically, a vision of the successful student is one who is a critical thinker and problem solver, interpersonally successful, knowledgeable and literate, self-directed and self-reliant, and an interested and involved citizen."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

Science Reform

The need to overhaul the delivery of science instruction is very real. With national attention on poor student performance, declining national competitiveness, and future labor shortages, the support for restructuring the teaching of science is widespread. As this century draws to a close, the volume of scientific content is staggering. In periods of less than ten years, the amount of scientific information doubles. How can students be expected to learn all there is to know about science topics? The time has come to determine what is essential to be learned and what skills will serve as a basis for lifelong learning.

The American Society for Engineering Education, through its Engineering Deans Council and Corporate Round Table, says that all engineering education programs must be RELEVANT, ATTRACTIVE, and CONNECTED. We believe this also holds for K-12 education. School systems and teachers must provide science education programs that are:

* *Relevant* to the lives and careers of students, preparing them for a broad range of careers, as well as for lifelong learning involving both formal programs and hands-on experience;

* *Attractive* so that the excitement and intellectual content of engineering, mathematics and science will attract highly talented students with a wider variety of backgrounds and career interests - particularly women, underrepresented minorities and the disabled - and will empower them to succeed; and

* *Connected* to the needs and issues of the broader community through integrated activities with other parts of the educational system, industry, and government (American Society for Engineering Education, 1994).

As a spin-off of the mathematics document Everybody Counts, the American Association for the Advancement of Science (AAAS) gathered a distinguished group of scientists and top educators to develop a set of recommendations on what understanding, skills, and attitudes are essential for all citizens in a scientifically literate society. The resulting document, Science for All Americans, and its accompanying document, Benchmarks for Science Literacy, differs in several basic respects from most other reform efforts in that it is:

Comprehensive. Reform must address the entire educational system.

Zero-based. Reform must start from scratch. The common core of knowledge and habits of mind must be established.

Focused. "Less is more." The present curriculum is overstuffed and undernourished. Teaching fewer concepts to a higher degree of understanding will help students better understand the principles of science.

Teacher centered. Teacher revitalization is critical to the success of the reform initiative.

Collaborative. Teachers cannot do the job alone. They need the help and cooperation of other teachers, administrators, parents and community leaders, students, university faculty, business and industry leaders, policy makers, scientists, mathematicians and professional associations.

Long term. The necessary changes will take decades to accomplish.

In line with Science for All Americans, the National Science Teachers' Association has developed a project titled Scope, Sequence, & Coordination of Secondary Science for grades 7-12. The project advocates carefully sequenced, well coordinated

instruction so that students begin with descriptive and concrete elements of science, proceed to the quantitative and more abstract, and conclude with theory building. Fewer topics taught over the seven years will result in greater student understanding of science and serve to better address problems and issues of scientific and technological dimensions in the future.

Call for Systemic Changes

The NCTM Standards and Science for all Americans documents have collectively delineated a number of areas in mathematics and science education--including curriculum, instruction, and assessment--where fundamental restructuring is needed. A summary of needed changes would include the following:

Curriculum Development. Statewide frameworks which have been developed for mathematics and science education can be a fruitful starting point for local curriculum development.

Textbooks, Technology, and other Materials. The curriculum in many schools is driven by textbooks. Textbooks should not drive curriculum, even if the books have been recently revised. Calculators, computers, courseware, manipulative materials, and well equipped laboratories are necessary for quality mathematics and science programs. Textbooks should be viewed as simply another form of ancillary support material for student learning rather than the curriculum.

Tests. According to research, what is tested is taught. If problem solving and higher order thinking are the focus of the reform program then a new generation of tests that focus on these areas must be developed. Rhode Island is committed to the development of such tests.

Instruction. Because students need to be active learners teachers must use a variety of teaching methods, grouping techniques, and approaches to assessment.

Teacher In-Service Programs. Many teachers are now ready to teach the kinds of science and mathematics being advocated. Many others will need additional training and refresher courses. In-service courses must be developed in collaboration with teachers.

Teacher Education. Colleges of education and science and mathematics departments need to reconsider their programs in light of the kinds of knowledge and teaching models proposed in national and state reports.

Students with Different Needs and Interests. All students can benefit from high quality mathematics and science programs. This can be accomplished by developing a core curriculum for all, and expanding and enriching this core to meet the needs of each individual student.

Equity. Instructional activities and programs must be developed to encourage more students, especially young women and minorities, to pursue careers in science and mathematics. Every school system should have in place a framework for determining that all students have equal opportunities to learn (Stevens, 1993; Rauth, 1994).

Working conditions. In many schools, teachers will find it difficult to teach the topics or create the instructional environment envisioned in these documents because of local constraints on curriculum and facilities. Teachers often lack resources and opportunity to meet and share ideas with other teachers. The work environment must empower teachers to make curriculum decisions and must include and support professional activities.

The above changes, based on the NCTM Standards and Science for all Americans, can help to insure that all Rhode Island students have both a suitable and sufficient background as they enter the 21st century.

Over 10,500 teachers currently provide instruction to the 145,000 public school students who attend the 302 schools in the 36 public school districts of Rhode Island. Approximately 3,500 of these are elementary classroom teachers who are responsible for providing instruction in the areas of science and mathematics. Another 750 teachers are content area (mathematics or science) specialists teaching in middle schools, junior highs, or high schools. The districts range in size from the largest (Providence) which serves approximately 23,000 public school students of whom nearly 70% are minority, to New Shoreham (Block Island) serving approximately 118 students. Some districts, such as Foster/Glocester and Exeter/West Greenwich, have regionalized to improve services and consolidate costs. An emerging trend has been the establishment of educational collaboratives. These collaboratives (Northern Rhode Island, Southern Rhode lsland, East Bay Educational, and West Bay), although differing in their priorities and levels of organizational development, share some common features. All are intended to achieve fiscal economy while improving services to member districts and retaining the local autonomy of the individual school districts.

In addition to its public elementary and secondary school population, the state also has approximately 26,000 students in grades K-12 who attend private or parochial schools, and approximately 68,000 (39,000 in public) students enrolled in

undergraduate programs in the public and independent institutions of higher education.

As we approach the 21st century, we want Rhode Island students to meet the highest national and international standards. Rhode Island students currently have similar achievement levels to United States students as a whole. The key to interpreting this information is to recognize that national performance results are far below what they should be. Many reform efforts nationwide are now committed to setting and achieving higher standards.

A key indicator of national performance comes from the National Assessment of Educational Progress (NAEP). The National Education Goals Panel, in its September 1993 report on progress toward the national education goals, adopted the NAEP 'proficient' definition as its target performance goal for all students. However, in the 1992 NAEP mathematics assessment, no more than a quarter of United States students met this target level.

Within Rhode Island, there are major differences in the educational achievement of students when one compares the average performance levels of different groups. These differences may be so large that they virtually guarantee lack of opportunity, limited employment opportunities and a life of barriers for a great many students (Rhode Island Department of Elementary and Secondary Education, 1995).

Student "persistence" in science

In addition to less than acceptable achievement levels, another serious dilemma facing the nation and Rhode Island is the diminished student interest in mathematics, science and engineering as they progress through the system. Student participation in science is virtually cut in half by ninth grade; cut again in half as they enter college science courses; and cut again in half as they enter post graduate and doctoral programs. In Rhode Island these factors are reflected in a relatively high dropout rate of 18%, a rate that ranges up to over 35% in our urban areas that serve large numbers of minority students. The situation is even more discouraging when one examines the limited number of students with ability in science who are interested in entering the teaching profession. This is particularly evident in the minority teaching base in Rhode Island where of the 750 teachers of secondary science and mathematics in public schools, there are fewer than ten science or mathematics teachers who are of African-American descent.

RECOMMENDATIONS

The status of mathematics and science education in Rhode Island is generally reflective of the nation as a whole. While Rhode Island has taken some significant strides toward addressing its problems in the areas of mathematics and science, much remains to be done. Toward these needed actions the following recommendations for the state as a whole, school districts, and individual schools are made:

Curriculum Frameworks:

Local curriculum frameworks for mathematics and science education, K-12, which align with the NCTM Standards and the Science for All Americans report must be developed. This state science framework and the state mathematics framework are the first step in this process. These curriculum frameworks:

· Provide a vision of high standards for student achievement by including:

- Student curriculum benchmarks and sample activities
- Teaching strategies through vignettes from RI classrooms
- Program goals and evaluation advice
- Assessment strategies
- Related materials and resources

· Guide districts and schools in formulating local curricula

· Drive the succeeding recommendations in this chapter

· Provide a model for post-secondary curriculum frameworks that will ensure a smooth transition from secondary school to college

Professional Development:

Efforts need to be undertaken to attract, train, and retrain teachers and administrators who are capable of implementing the content and teaching approaches described in the RI mathematics and science curriculum frameworks.

· In-service programs are needed that will provide high quality, long-term training to all current teachers and administrators as they work to develop and implement changes consistent with their schools' mathematics and science programs.

· Undergraduate teacher preparation programs need to be reviewed and revised to ensure that they adequately prepare new teachers to teach in ways consistent with the curriculum frameworks and current research.

· Teacher certification requirements need to be revised to include standards that result in well-prepared teachers of mathematics and science. Flexibility must be provided for certification of teachers in those districts that engage in experimental practices.

· Current efforts to recruit and retain high quality teachers into careers as mathematics and science teachers, particularly from those groups historically under-represented, need to be expanded.

Access and Equity:

Special efforts need to be undertaken to insure that ALL students have an opportunity to experience a high quality mathematics and science program. Schools need to increase motivation, incentives, and opportunities for all students to pursue study and/ or careers in mathematics, science, and related fields. In particular, the state, districts, and schools need to:

. Provide alternative paths to learning goals for students including the use of varied instructional approaches.

· Support efforts such as magnet programs in mathematics and science and centers for talented students, develop alternatives to the tracking system, and provide greater access to positive role models.

· Assist teachers and parents to overcome stereotypes, provide early intervention and counseling, and stress technology related careers.

· Encourage active engagement of parents and communities in mathematics, science, and technology programs to increase participation by under-represented groups.

· Use college outreach programs, dual enrollment, advanced placement, and financial aid awards in post-secondary institutions to target under-represented groups for mathematics, science, and technical studies, with a special emphasis upon those preparing to be teachers of these subjects.

Learning Environment:

Responsibility and support must be given to local schools and teachers to develop and experiment with their own ways of using time, space, materials, and human resources in the student learning environment. The learning environment should include:

- The system of professional development for school personnel and pre-service training for those entering education is not adequate to meet the needs of a restructured school environment.
- The new realities facing public education -- the dissolution of the family, the lack of school readiness, the hunger and physical and emotional neglect of students -- affect the system's ability to be successful with many students. Solutions to educational problems that focus on the school system alone will continue to fail."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

· Equipment, objects, and other "things" that students can get their hands on to observe, measure, sort, and use in doing mathematics and science.

· Alignment with the state curriculum frameworks.

· Use of educational technology that is incorporated into the mathematics and science courses as an integral part of the curriculum.

"In the past, teaching and learning policies -- those related to curriculum, instruction, assessment, and teacher preparation -- frequently emphasized inputs such as courses offered and time on task. In the future, policies must be focused on outcomes -- on a commitment to provide all students with basic knowledge and higher level thinking skills."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

· Use of the mathematics-rich and science-rich resources in the community, such as business and industrial sites, museums, zoos, technology, and environmental education centers.

· Common planning time for teachers engaging in innovative classroom practices.

Outreach:

Schools and teachers need to promote community awareness of the need to reform science and mathematics education. Schools must develop and expand partnerships with public policy makers, community leaders, colleges and universities, hospitals, museums, business and industry to create a solid network of support.

· The Governor and state agencies can play a leadership role in building public support for systemic change in science, mathematics, and technology education as part of an economic recovery strategy.

· The Legislature can support school boards through legislation that provides mathematics and science program incentives, or loan forgiveness for those who become mathematics and science teachers.

· Business and industry can provide technical assistance, equipment, volunteers, and internship opportunities for students and teachers.

· Community leaders can publicize exemplary school programs and address civic organizations and parent groups on awareness of the need for change.

Support:

Efforts must be undertaken to direct resources to the reform of mathematics and science education. Although this will certainly require some additional investment of resources, innovation in the ways current resources are coordinated and expended need to be encouraged. Several existing sources of funds (e.g., Goals 2000 monies; IASA funds, especially Chapter 1 and Title 2; Literacy funds) need to be aligned with each other and with the state's frameworks and goals for mathematics and science instruction. In addition, aggressive attempts to secure other additional funds from federal and private funding sources need to be undertaken to provide resources to supplement state efforts.

Conclusion

Preparing Rhode Island students to be informed citizens and well educated workers for the workplace of tomorrow will not be easy, quick, or without costs. It is important to realize that the changes needed in mathematics and science education will not only improve our economic competitiveness, they will also begin the needed process of reform and change throughout our state's school systems. Many of the changes called for in this section of the science framework do not involve increased costs, nor must they all be done at once. The reform of mathematics and science education is a statewide priority, and the process of reform needs to continue and deepen. Only by involving all the key actors at the school, community, district, and state levels, can we hope to reach our goal.

"School finances must be based on equity, adequacy, tax fairness and effectiveness.

Rather than focus on equal dollars, the finance system must address equal learner outcomes, and funding reforms should be connected to both adequacy and improved learning and teaching practices. The manner in which the state distributes financial aid must not ignore strategies for making schools more effective."

Educating ALL Our Children, A Report of the 21st Century Education Commission, March 1992.

"The governance system must be structured to support student achievement. Accountability and responsibility for learning should be assigned to those closest to the student if the diverse and complex needs of children are to be met. Barriers to ensuring student success must be removed. The governance system must be based on the concept that form follows function and that leadership can originate at all levels when empowered by a shared vision."

Educating ALL Our Children
A Report of the 21st Century
Education Commission
March 1992

Cumberland School District
Cumberland, Rhode Island
Town-Wide Activity

A Unique Approach to Financing Technology

"... through the gift of computer access, the community will be empowering students with skills for their lifetime: the skills needed to explore, understand, and solve the problems of the real world."

Computers in Classrooms, a plan by Mayor Edgar R. Alger III, Cumberland, RI

Cumberland's Systemwide Technology Committee created a multi-year technology plan for the district's schools K-12. While many school districts are working on plans of this type, Cumberland may have found an innovative solution to financing the equipment called for by this plan -- by having the COMMUNITY develop the plan and be responsible for its success. The Technology Committee defined a basic level of service for an elementary, a middle level, and a high school classroom. They also added basic services which should be available at each school or department and administrative office. They have pledged to provide every classroom with basic services BEFORE any additional items are added. For example, the 'middle school classroom basic computer standard' consists of two networked computer/media centers with Apple Macintosh stations; four Apple MacIntosh computers, CD/ROM and a networked printer. Other desirable classroom items include a large screen display, an additional CD/ROM and an additional computer, but these would not be purchased until every middle school classroom in the system has met the basic levels. The technology plan also details how curriculum and instruction need to be modified and the type of staff training and support required.

A funding partnership is being solidified between the Town, the School Department, the State, local businesses and foundations, and parents groups. Mayor Edgar R. Alger III has released a written plan called Computers in the Classroom which outlines 'Cumberland's Commitment to Excellence in Education.' In addition to the commitment of substantial funds from the town and the school department, the Mayor has secured funding from several businesses and foundations. The final funding piece comes from the local PTA's and PTO's, who are being asked to contribute $2,000 per group per year of the plan.

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